At present cast hot work dies made from medium alloy high heat resistance steels have obtained wide use. However, the service life of such dies is unstable and there are frequent cases of their early failure. The coarse fracture and coarse grain characteristic of dies in the cast condition still occurs after annealing and final heat treatment. As is known, the presence of such a structure causes low toughness in steel and has a negative influence on the life of a cast die.

In this work an investigation was made of the influence of annealing temperature on the impact strength and character of fracture after tests at different temperatures of samples of cast 4Kh5MFSNB steel, which is used at Kamaz Truck Plant for the production of hot work inserts. The annealing was done at 850–1200°C for 15-20 h. To accelerate pearlitic decomposition the samples were tempered at 700°C for 5 h before annealing.

Impact samples were cut from the center portion of the casting (zone with a structure of equiaxial grains) and from its surface layers (zone with dendritic structure).

It was established that all of the samples have a low impact strength (0.6–1 MJ/m²) which is practically unchanged in relation to annealing conditions, test temperature, and place of cutting the samples.

The microstructure of 4Kh5MFSNB steel after annealing at various temperatures is shown in Fig. 1.

It may be seen that after annealing at 850°C the coarse grain corresponding to the cast condition is maintained. After annealing at 1000°C and higher the austenitic grains are refined. The higher the annealing temperature, the more intense the process of formation of the boundaries of new fine grains but after annealing...
Macrofractures of 4Kh5MFSNB steel after tests at 20°C (a-e) and 300°C (f-i) in relation to annealing temperature. ×5. a, b, f, g) at 850°C; c) 1000°C; d, i) 1150°C; e, k) 1200°C; h) 1100°C.

at all the investigated temperatures, partially preserved boundaries of the coarse primary grains are observed.

With a test temperature of 300°C the character of the fracture of samples annealed at 850°C for 15 h is determined by the point of cutting the sample, dendritic if the sample is cut from the zone of dendritic structure (Fig. 2f) and random and intergranular if the samples is cut from the zone with an equiaxial structure (Fig. 2g). After annealing at 1000-1150°C the fracture becomes more dispersed and its dendritic structure is weakly expressed and practically absent after annealing at 1200°C (Fig. 2h-k).

Microfractographic investigations of the samples were made on Tesla BS-613 light and Cambridge S4-10 scanning electron microscopes (Fig. 3). For the analysis of the microstructure two-stage carbon replicas were used on the transmission electron microscope.

In the investigation on the scanning electron microscope of the fractures of samples annealed at 850°C after impact testing at 20°C their sharply expressed dendritic structure is observed (Fig. 3a). Individual areas of the microfracture have a "river pattern" and "tongue" structure, which is characteristic of intergranular fractures (Fig. 3b). However, together with the "river pattern" in each area of the fracture there is observed a definite microgeometric relief passing along the dendritic columns as the result of brittle rupture in the boundary of the dendrites (Fig. 3c). With an increase in annealing temperature the area of the portions with the river pattern increases and that of the portions with the microgeometric relief decreases and after annealing at 1150-1200°C primarily river pattern is observed in the fracture. Obviously the boundaries between the dendrites are the weakest element in the cast structure. The processes of diffusion occurring at high annealing temperatures (1100-1200°C) to a significant degree promote the elimination of dendritic segregation in 4Kh5MFSNB steel, as the result of which fracture occurs in the body of the grains by quasicleavage or partially in the former austenitic grain boundaries. Probably the austenitic grain boundaries are a barrier to crack advance and that is why steps are observed in the macrofracture and a change in quasicleavage direction in the microfracture. Therefore, at room temperature fracture of the samples of cast steel after annealing at 850°C occurs along the dendritic columns and after annealing at 1150-1200°C intergranularly.

The fractures of samples annealed at 850°C and tested at 300°C (investigation of a scanning microscope with a magnification of ×100-300) have together with the dendritic a granular structure (Fig. 3d). At high magnifications it may be seen that the individual facets of a fracture with a granular structure have a relief reminiscent of the dendritic structure of the macrofracture (Fig. 3e) and on some facets a "pitted pattern" is observed. Intergranular fracture at carbide inclusions, which are encountered on the primary austenitic grain boundaries, is not observed. It may be assumed that fracture occurs not in the primary grain boundaries but in the dendrites of the cast structure. It is obvious that even the austenitic grain boundaries weakened by carbides